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POTATO WART

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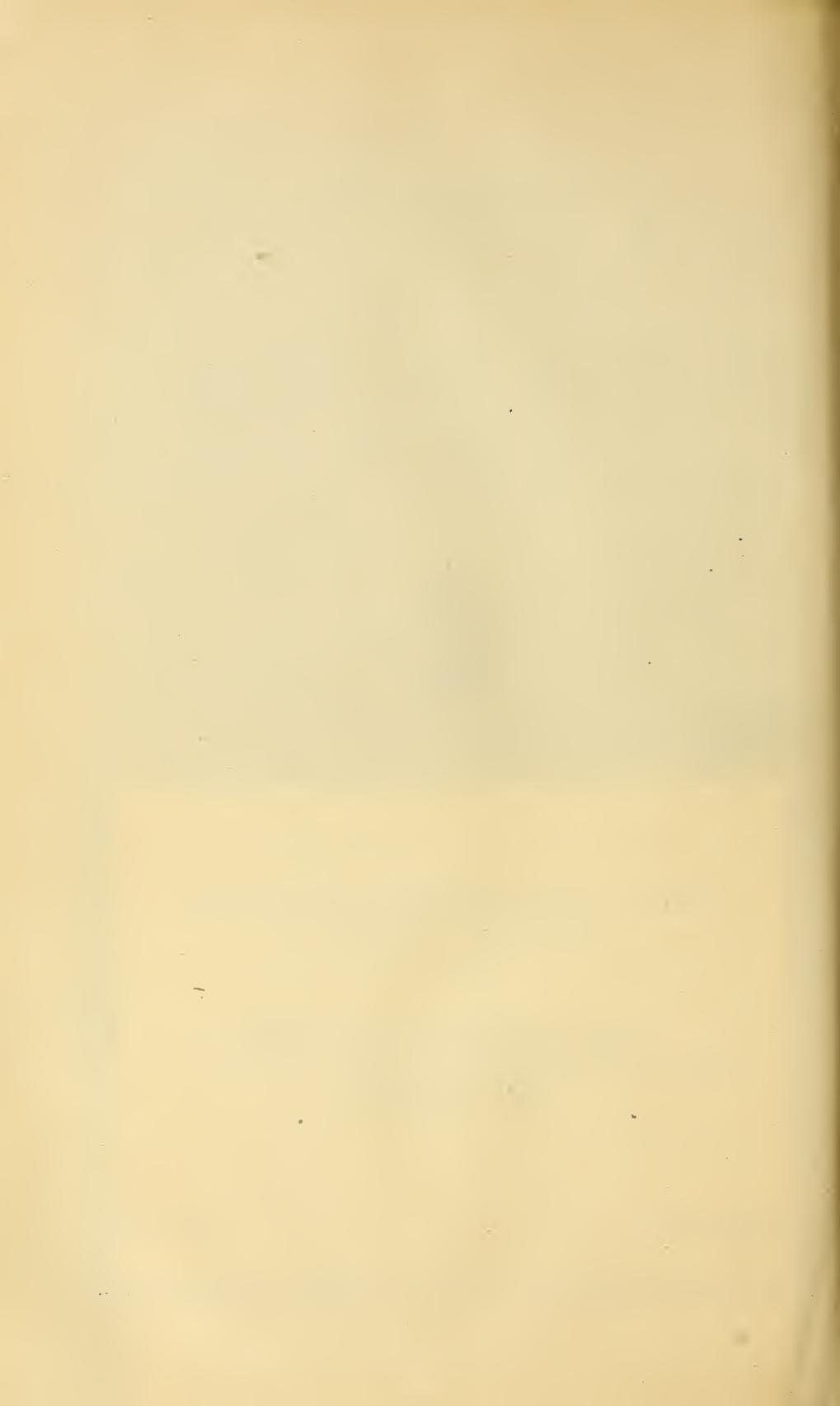


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POTATO WART IN THE UNITED STATES.

By G. R. LYMAN, *Pathologist in Charge of Plant-Disease Survey.*

THE discovery in the United States in 1918 of potato wart, one of the most dangerous European diseases of the white potato, presents another serious problem to the growers of one of our most valuable food crops. This disease has been gradually spreading in northern Europe for many years and is so serious in certain regions that in 1912 the United States Department of Agriculture placed an embargo on potatoes coming from countries where the wart was known to exist, in the hope of keeping it out of this country. In September, 1918, the disease was discovered in gardens at Highland, Pa., in the heart of the anthracite mining district, and was reported by the Pennsylvania State Department of Agriculture. A hasty survey of that region showed that wart was present in many of the mining villages of Luzerne, Schuylkill, and Carbon Counties, the infection being so severe in some gardens as practically to destroy the crop.

The infested area in Pennsylvania was immediately quarantined and every precaution taken to prevent the further spread of the disease. Plans were formed to investigate the nature of wart, to determine its distribution in the United States, to experiment on the practicability of eradicating it from infested areas, and to test both native and foreign varieties of potatoes for resistance to the disease.

¹ The experimental work reported upon in this circular was conducted cooperatively by the Bureau of Plant Industry, the Federal Horticultural Board, and the Pennsylvania Agricultural Experiment Station.

HOW THE DISEASE REACHED THE UNITED STATES.

The embargo against potatoes from countries known to harbor wart became effective on September 20, 1912. Before it took effect, however, several million bushels of the crop of 1911 were imported from England, Ireland, and other European countries, and large quantities of these potatoes were distributed in the mining districts of Pennsylvania where wart was found in 1918. Other heavy importations of potatoes had also been made during previous years. Owners of gardens in the infested section of Pennsylvania stated that they had observed wart on their potatoes for several years, and it is probable that the disease gained entrance to this country on the potatoes imported during 1912 or earlier. Undoubtedly some or many of these lots were diseased. Although the imported potatoes were sold as table stock, occasional plantings may have been made, and the common practice of throwing potato peelings upon the garden or of feeding them to domestic animals would serve to introduce the parasite into the soil if wart chanced to be present.

SURVEY TO DETERMINE THE DISTRIBUTION OF WART.

Knowledge of the present distribution of wart in the United States was essential before practical methods of control or eradication could be determined. Therefore, during 1919 the Plant-Disease Survey, in cooperation with the Federal Horticultural Board, conducted a field search in an effort to find how widely the disease had been introduced. In organizing and conducting this survey attention was given to the following considerations:

(1) The whole United States must be included in the search. For many years prior to 1912 potatoes had been brought in from northern Europe, the importations amounting to many millions of bushels during years when the American crop was short. New York was the chief port of entry, but large consignments were also received at many other Atlantic and Gulf ports. It was not possible to obtain complete data on the ultimate destination of all these shipments, but investigation of the 1912 importations at New York revealed the fact that these potatoes had been very widely distributed, going in carload lots as far south as Florida and Texas and as far west as Nebraska, while smaller consignments even reached the Pacific coast. Importations at other ports were also widely distributed, so that during 1912 and previous years practically all parts of the United States received European potatoes. Since many of these shipments may have contained warty tubers it is quite possible that the disease had been introduced in many places where foreign potatoes were distributed. Therefore, the whole United States was under suspicion of having received this new disease, although the danger was manifestly greater in the Eastern and especially in the Northeastern States, where the consumption of the foreign potatoes had been heaviest.

(2) The disease was more likely to be found in home gardens of cities or towns than in agricultural districts. It appears that the foreign potatoes found ready sale in cities and in industrial and mining centers, especially those with a large foreign population, while the country districts bought more sparingly and hence were in less danger of receiving the disease. Moreover, a disease as conspicuous and destructive as wart could hardly go unobserved and unreported indefinitely by the intelligent potato grower. On the other hand, the city dweller, the miner, or the industrial worker having a small home garden, ignorant of agricultural matters and out of touch with county agents and

other agricultural experts, often with little knowledge of the English language or of American institutions, might fail to report the disease for many years, even if he chanced to observe it. Meantime, his infested garden would continue to be a menace to neighboring gardens and also to the surrounding farming districts.

(3) The best time to search for wart is at digging time. The disease attacks the underground parts of the potato plant, destroying the tubers but not affecting the tops. Hence, it is not readily detected by observing the growing plant. The warts are prominent on the tubers as they come from the ground, but readily break off and decay in storage, making bin inspection less certain to produce positive results. Therefore, it was necessary to begin the survey in the Southern States with the harvesting of the early crop in May and to work northward with the digging season.

It was evident that to carefully inspect the potato crop of the United States at the time of digging, paying special attention to home gardens in cities and in centers of foreign population, and increasing the intensity of the search as the Atlantic seaboard was approached would be well nigh an impossible task. Only by securing the interest and active cooperation of intelligent people throughout the United States did the undertaking appear to be practicable. Fortunately, the warts on the potatoes are so conspicuous and characteristic as to be easily recognized even by those unskilled in plant diseases, so that cooperation on a wide scale, as suggested above, could be made of practical value.

PUBLICITY CAMPAIGN.

Much attention was given to a publicity and educational campaign designed to arouse the interest of both growers and users of potatoes, to acquaint them with the nature and appearance of the disease, and to impress them with the importance of watching for it and of reporting it should it come to their attention. This educational campaign was carried on in close cooperation with the State pathologists who are collaborators of the Plant-Disease Survey and with other officials of the State agricultural experiment stations. A special field agent of the Plant-Disease Survey was placed in each State to assist the collaborators in organizing the work and in securing the general interest and cooperation sought. Effective assistance was given by the information services of the United States Department of Agriculture and of the several States. Illustrated printed matter was prepared and distributed widely as follows:

(1) An illustrated circular entitled "Wart of Potatoes: A Disease New to the United States" (C., T., and F. C. D. Cir. 6; pp. 1-14, 1919), prepared by Dr. L. O. Kunkel, of the Office of Cotton, Truck, and Forage Crop Disease Investigations, available for those desiring rather full information about the disease.

(2) An illustrated 4-page folder (Dept. Cir. 32) giving the essential facts about wart from the point of view of the average person, available in large quantities.

(3) Illustrated post cards giving a few facts about the disease and emphasizing the importance of reporting suspicious cases, available in very large quantities for wide distribution.

In addition to the printed matter furnished and distributed by the Plant-Disease Survey, illustrated circulars, cards, and posters were

prepared by a number of the States. As many as possible of the officials and private individuals who could aid in the search for wart were personally visited and their assistance enlisted. Among those who became interested in potato wart as a result of this educational campaign and who actively cooperated in the search for the disease may be mentioned the following:

(a) Federal, State, and private pathological workers, many of whom gave freely of their time in organizing the work, in passing upon suspicious specimens sent in for examination, and in actual garden inspection.

(b) Horticulturists, agronomists, and members of various agricultural departments in State colleges and experiment stations.

(c) All branches of the Extension Service, especially the county agents and agricultural clubs of various sorts. The county agents cooperated most effectively in distributing literature and in arousing in other ways the interest of potato growers in the disease. They also rendered invaluable assistance to those inspecting gardens in their counties.

(d) State departments of agriculture, plant boards, and all branches of the inspection service.

(e) Faculty members and students of colleges and universities, many of whom took an active part in the campaign.

(f) School children, who became interested through their teachers. In many localities the teachers and school children were of great service, especially in the non-English speaking communities where the wart was most likely to be located and where the difficulties of inspection were greatest. Here they disseminated information about the disease, reported suspicious cases, and acted as guides and interpreters to the garden inspectors.

(g) Garden clubs and similar associations which were of great assistance in many localities.

(h) Postmasters, chambers of commerce, boards of trade, and many other public and private officials and organizations, which were always ready to cooperate.

(i) The public press, including both city and country newspapers and farm journals of all kinds. Papers printed in foreign languages were found of great assistance in reaching non-English speaking classes.

(j) The clergy, especially those serving foreign-language congregations. They rendered invaluable aid in foreign-language communities where inspectors were frequently regarded with suspicion until properly accredited.

(k) Potato dealers and distributors of potatoes.

(l) Potato associations and individual potato growers.

(m) The Boy Scout organization, which gave much valuable assistance.

The response received from this educational campaign was most gratifying, and the results obtained fully justified the efforts put forth. Thousands of suspicious tubers were received by the Plant-Disease Survey and the State experiment stations for examination. So general was the interest aroused that it seemed hardly possible that wart could remain unreported by interested observers if present in a farming community. The same was also true of the towns and smaller cities, especially those situated in prosperous agricultural sections. Therefore, in such localities no garden inspection of potatoes by special field agents of the Plant-Disease Survey was undertaken.

GARDEN INSPECTION.

Very different conditions were found in the larger cities and in industrial and mining regions, especially in those with large immigrant populations. The people in such localities are usually not in touch with county agents and other agricultural workers and know nothing of modern agricultural practices relating to plant-disease control. Often they are total strangers to our language and to American customs and activities. While carefully planned educational work on the wart disease met with a fair measure of response in such localities, the results could not be compared with those obtained in agricultural communities. Hence, greater effort was made in such places to secure inspection of potatoes by special field agents. It was not possible in the time and with the funds available to inspect thoroughly all the home gardens in localities of the type mentioned above, but careful selection was made in consultation with State collaborators and other local advisers of those localities which for any reason seemed especially deserving of attention, and careful inspection was given the potatoes grown there. In addition, innumerable examinations were made of occasional fields and gardens in localities regarded as less suspicious.

• WART FOUND IN PENNSYLVANIA AND WEST VIRGINIA.

On August 27, 1919, Mr. L. E. Yocum, a field agent of the Plant-Disease Survey, found wart in a garden in Nanty Glo, Cambria County, Pa., a bituminous coal-mining village of foreign population, about 180 miles west of the infested area about Highland in eastern Pennsylvania. Two days later Field Agent Ernest Angelo found the disease in a garden in Whitmer, Randolph County, W. Va.

Immediately after these discoveries a careful search of all gardens in those neighborhoods was undertaken, and the intensive survey was continued and extended from those localities as centers until the potato crop was fully harvested and further work became impracticable. In Pennsylvania the survey was in cooperation with Prof. C. R. Orton, plant pathologist of the Agricultural Experiment Station at State College, and wart was discovered in six villages as follows, the first four mentioned being in Cambria County: Nanty Glo, where two gardens were found to be infested; Lilly, with 1 infested garden; Llanfair, with 10 gardens; Vintondale, with 2 gardens; Osceola Mills, Clearfield County, with 5 gardens; and Clarence, Center County, with 2 gardens. Field agents of the Pennsylvania State Department of Agriculture also surveyed a number of counties in western and southwestern Pennsylvania, but found no additional points of infestation. In West Virginia the survey was in cooperation with Dr. N. J. Giddings, plant pathologist of the Agricultural Experiment Station at Morgantown, and resulted in the discovery of

wart in two villages; Whitmer, Randolph County, with a single infested garden; and Thomas, Tucker County, where 11 gardens were found infested. Hundreds of other villages in Pennsylvania and West Virginia were visited by the field agents and all gardens where potatoes were grown, many thousands in number, were carefully examined without finding wart.

All six villages where wart was found in Pennsylvania are mining settlements in the bituminous section of the State and are inhabited largely by foreigners. Thomas, W. Va., is also a soft-coal mining village, but the miners are largely of American descent. Whitmer, W. Va., is a small sawmill village and is the only point of infestation found outside the mining area. None of the towns mentioned are located in agricultural sections, although a potato-raising industry of some importance is developing not far from Whitmer. Careful examination of all gardens in the villages where wart was found showed that the area of infestation was limited in every case, usually being restricted to one or two gardens. It was not possible to obtain conclusive evidence from the inhabitants showing how long the disease had been present or what had been its origin. In many gardens the infestation was severe and the yield of potatoes seriously reduced.

DANGER OF WART ENTERING THE UNITED STATES FROM NEWFOUNDLAND.

Wart is known to exist in Newfoundland and the neighboring islands of St. Pierre and Miquelon. Although the importation of potatoes from these islands was prohibited by the quarantine of 1912, there is danger of potatoes being brought back by New England fishing boats which visit the Grand Banks. One town was found in Maine where this has actually occurred. Fishing boats during seasons when a light catch of fish coincides with a poor potato crop at home have occasionally attempted to recoup their losses by bringing back cargoes of Newfoundland potatoes, which were landed without inspection by the customs officials charged with enforcing the quarantine laws. These potatoes were consumed locally, but search in that region failed to show that wart had been introduced. However, there is grave danger that the disease may be introduced in this manner along the New England coast.

PROBABLE DISTRIBUTION OF WART IN THE UNITED STATES.

As a result of the nation-wide search for wart in 1919 six infested villages were discovered in western Pennsylvania and two in northern West Virginia. During the summer, field men of the Pennsylvania State Department of Agriculture intensively surveyed the infested district about Highland, extending and more exactly delimiting it. Therefore, at the present time wart is known in one large area falling within the anthracite mining section of eastern Pennsylvania, in six villages in the bituminous section of western Pennsylvania, and in

one mining village and one sawmill hamlet of northern West Virginia. (Fig. 1.)

It is highly significant that all eight of the new locations of wart discovered during 1919 are small and in no way comparable to the extensive Highland district, and it is believed that no other extensive area exists in the United States. It is hardly possible that such areas could have been overlooked in the survey of 1919, which included not only the actual inspection of potatoes in those regions judged to be especially worthy of attention, but also a thorough educational campaign which covered all parts of the United States. The effectiveness



FIG. 1.—Outline map of the States of Pennsylvania and West Virginia, showing the present known distribution of potato wart in the United States. The large Hazleton-Freeland and Beaver Meadows area of infestation is shown in black, irregular outline; scattered infestations are shown by black dots.

of this educational work in leading to the discovery of wart is proved by the fact that four of the eight points of infestation found in the summer of 1919—two of those in Pennsylvania and both of those in West Virginia—were reported to our field agents by citizens who became interested on account of the educational campaign. One of these four reports came from a traveling salesman, and the others from a farmer, a postmaster, and a school-teacher.

While it is probable that large infested regions would have been found by this survey, small areas, or those where the infestation is slight, might easily have escaped discovery. Undoubtedly, other villages with infested gardens occur in Pennsylvania and West Virginia, and further intensive search is needed in certain parts of those

States. It is possible that small points of infestation occur in other States, but present evidence seems to indicate that the disease is limited to a region more or less coincident with the eastern coal-mining section and that the Highland district is the only extensive area. Nevertheless, both growers and users of potatoes throughout the United States should maintain a vigilant watch for wart and report all suspicious cases to the nearest State agricultural experiment station.

THE BEHAVIOR OF AMERICAN POTATO VARIETIES IN THE PRESENCE OF THE WART.

By L. O. KUNKEL, formerly *Pathologist, Office of Cotton, Truck, and Forage Crop Disease Investigations*, and C. R. ORTON, *Collaborator, Office of Plant-Disease Survey.*

The reaction of varieties of potatoes to the wart has furnished one of the most striking instances of resistance and immunity in plants.

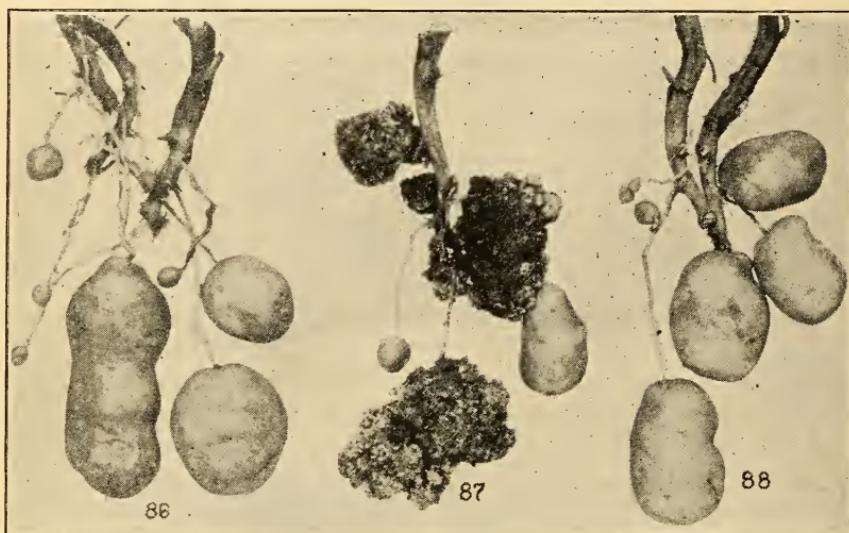


FIG. 2.—Effect of the wart on different American varieties of potatoes planted in infested gardens near Freeland, Pa., in 1919: 86, Ehnola, immune; 87, Early Sunrise, susceptible; 88, Extra Early Sunlight, immune.

While most varieties are susceptible to wart, some are highly resistant, and a considerable number are absolutely immune. Several European countries have learned that the growing of immune varieties is a practical method of controlling the disease.

When wart was discovered in Pennsylvania a little more than a year ago, the question at once arose whether some of our American varieties would prove to be resistant or even immune. To test this question a number of varieties were grown on infested soil near Freeland, Pa., during the season of 1919.

In addition to commercial American varieties, a number of promising seedlings developed by Prof. William Stuart and 29 immune

English varieties were grown in wart-infested gardens. All of the gardens used in this test were observed to be thoroughly infested with the wart in the autumn of 1918. The Bliss Triumph variety, which was known to be susceptible to wart, was used as a check, and an occasional row was planted across each garden.

The gardens were plowed early in the spring and after being leveled and put in good condition were planted during the first few days of May. In most cases two rows of each variety were planted. The length of the rows varied somewhat in the different gardens, but they contained approximately 50 hills each.

The soil in all of the gardens is deep and fertile and seems well suited for the growing of potatoes. It is a clay loam to which large quantities of coal ashes and stable manure have been applied during past years. Shortly after the potatoes were planted a liberal supply of stable manure was spread over the surface of each garden. This

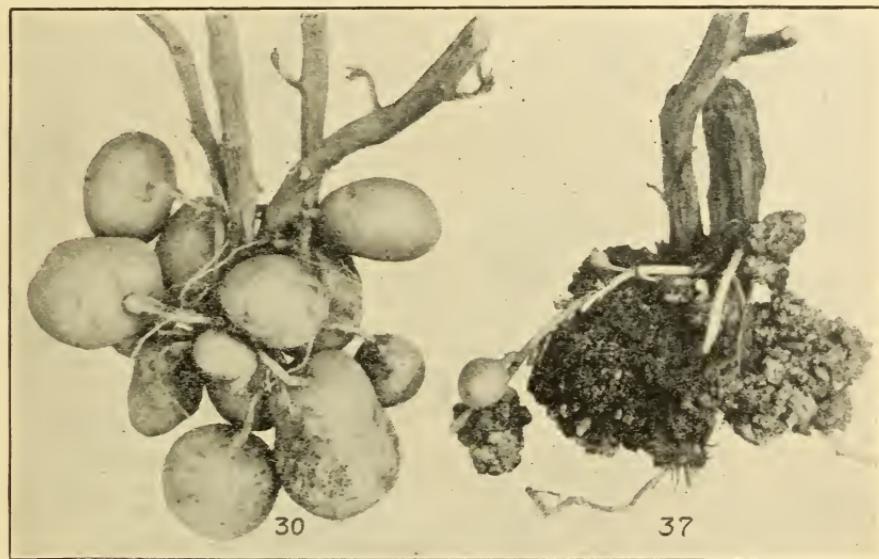


FIG. 3.—Effect of the wart on different foreign varieties of potatoes planted in infested gardens near Freeland, Pa., in 1919: 30, Arran Comrade, immune; 37, Eldorado, susceptible.

was later worked into the soil by cultivating it at frequent intervals with hand hoes. The season was favorable for potato growing, and most of the commercial varieties gave a heavy growth of vines. The resistant and immune varieties yielded a satisfactory crop. The potatoes were harvested September 8 to 18. Several times during the season notes were taken on the condition and health of the vines of the different varieties. In Table I these notes are presented, along with observations on the reaction of the varieties to the wart. The varieties are listed in the table in the same order in which they were planted in the gardens. Figures 2 and 3 illustrate the effect of the wart on some of the varieties planted.

TABLE I.—*The effect of the wart disease on different varieties of potatoes planted near Freeland, Pa., in 1919.*

Field No.	Variety name.	Reaction to wart disease.	Yield.	Notes on growth and health of vines.	Origin, group, or parentage.
1	White City.....	Immune.....	Fair.....	Vines small, healthy.....	English variety.
2	Irish Queen.....	....do.....	Good.....	Vines medium in size, healthy.....	Do.
3	Golden Wonder.....	....do.....	Fair.....	....do.....	Do.
4	Burnhouse Beauty.....	....do.....	Very poor.	Very small, healthy.....	Do.
5	Provost.....	....do.....	Fair.....	Fairly large, healthy.....	Do.
6	Bishop.....	....do.....	Very poor.	Poor stand, small, healthy.....	Do.
7	Snowdrop.....	....do.....	....do.....	Poor stand, fair size, healthy.....	Do.
8	Bliss Triumph.....	Moderately warted.	Good.....	Large vines, mosaic.....	Triumph group.
9	Great Scot.....	Immune.....	....do.....	Large vines, healthy.....	English variety.
10	Arran Rose.....	....do.....	....do.....	Fairly large, healthy.....	Do.
11	Templar.....	....do.....	Fair.....	Large, some mosaic and curly dwarf.	Do.
12	Tynwald's Perfection.	....do.....	Very poor.	Small, healthy.....	Do.
13	Bliss Triumph.....	Moderately warted.	Good.....	Large vines, mosaic.....	Triumph group.
14	Majestic.....	Immune.....	....do.....	Large, healthy.....	English variety.
15	The Duchess.....	....do.....	Fair.....	Medium to large, leaf-roll.	Do.
16	Bliss Triumph.....	Moderately warted.	Good.....	Large, mosaic.....	Triumph group.
17	....do.....	....do.....	....do.....	....do.....	Do.
18	Rector.....	Immune.....	....do.....	Large, small amount of mosaic.	English variety.
19	America.....	....do.....	Poor.....	Small, some mosaic and curly dwarf.	Do.
20	Nithsdale.....	....do.....	Fair.....	Large, small amount of mosaic.	Do.
21	Witch Hill.....	....do.....	....do.....	Small, poor stand, healthy.....	Do.
22	Abundance.....	....do.....	....do.....	Small, healthy.....	Do.
23	Dargill Early.....	....do.....	Poor.....	Small, considerable mosaic and curly dwarf.	Do.
24	The Ally.....	....do.....	....do.....	....do.....	Do.
25	Shamrock.....	....do.....	....do.....	Medium to large, healthy.....	Do.
26	King George.....	....do.....	Fair.....	Small, some leaf-roll.....	Do.
27	St. Malo Kidney.....	....do.....	Good.....	Large, small amount of mosaic.	Do.
28	Edzell Blue.....	....do.....	Excellent.	Large, healthy.....	Do.
29	Lochar.....	....do.....	Poor.....	Large vines, small amount of mosaic.	Do.
30	Arran Comrade.....	....do.....	Fair.....	Large vines, healthy.....	Do.
31	Bliss Triumph.....	Moderately warted.	Good.....	Large, mosaic.....	Triumph group.
32	Langworthy.....	Immune.....	Fair.....	Large, small amount of mosaic.	English variety.
33	Kerr's Pink.....	....do.....	....do.....	Large vines, healthy.....	Do.
34	Keeper.....	....do.....	....do.....	Medium to large vines, some curly dwarf.	Origin unknown.
35	Rural New Yorker No. 2.	Badly warted	Good.....	Large, healthy.....	Rural group.
36	Dalmeny Challenge.....	....do.....	Poor.....	Large vines, healthy.....	Foreign variety.
37	Eldorado.....	....do.....	....do.....	Poor vines, much mosaic and curly dwarf.	Do.
38	Dearborn.....	....do.....	Good.....	Large, healthy.....	Pearl group.
39	Producer.....	Very badly warted.	Fair.....	Large, showing some leaf-roll.	Up-to-Date group.
40	Arran Victory.....	Immune.....	Poor.....	Medium in size, some mosaic.	English variety.
41	S-37662.....	....do.....	Good.....	Large, some curly dwarf and mosaic.	Irish Cobbler × Early Petoskey.
42	S-38814.....	Moderately warted.	....do.....	Large, mosaic.....	Nonblight × Busola.
43	S-38678.....	Very badly warted.	....do.....	Large vines, some leaf-roll.	Nonblight × Zbyszek.
44	S-39215.....	Badly warted	Poor.....	Medium in size, slight mosaic.	Pres. Roosevelt × Busola.
45	S-39366.....	Very badly warted.	....do.....	Large vines, some mosaic.	Manila × Petronius.
46	S-38859.....	Moderately warted.	Excellent.	Large, slightly mosaic...	Nonblight × Petronius.
47	S-39324.....	Slighty warted.	Good.....	Large, healthy.....	Manila × Busola.
48	S-4240.....	Very badly warted.	Poor.....	....do.....	Prof. Maerker × Silver Skin.
49	S-17042.....	....do.....	....do.....	Large, considerable mosaic.	Early Excelsior × Apollo.

TABLE I.—*The effect of the wart disease on different varieties of potatoes planted near Freeland, Pa., in 1919—Continued.*

Field No.	Variety name.	Reaction to wart disease.	Yield.	Notes on growth and health of vines.	Or'g'n, group, or parentage.
50	S-38748.....	Badly warted	Poor.....	Medium size, much mosaic.	Rust proof×Busola.
51	Bliss Triumph.....	Moderately warted.	Fair.....	Large vines, much mosaic.	Triumph group.
52	S-38967.....	Slightly warted.	Excellent.....	Fairly large, healthy.....	Rural New Yorker × Busola.
53	S-39500.....	Moderately warted.	Good.....	Large, healthy.....	Irish Cobbler×Busola.
54	S-39215.....	Badly warted.	Poor.....	Medium size, slightly mosaic.	President Roosevelt × Busola.
55	S-3165.....	Immune.....	do.....	Small, some mosaic.....	Sophie×Irish Seedling.
56	S-39340.....	Warted.....	do.....	Large, slightly mosaic.....	Manila×Cacha negra.
57	S-38899.....	Immune.....	Fair.....	Medium in size, slightly mosaic.	Prosperity×Fairy's.
58	S-39304.....	do.....	do.....	Large, healthy.....	Dibble's Russet×McCormick.
59	S-39168.....	do.....	Poor.....	do.....	Green Mountain×Busola.
60	S-38759.....	Slightly warted.	Fair.....	Medium size, some mosaic.	Carman No.3×Busola.
61	S-39379.....	do.....	do.....	Very large, some mosaic.	Manila×Petronius
62	S-39247.....	Badly warted.	Good.....	Medium, healthy.....	Early Rockford×Petronius.
63	S-38461.....	Moderately warted.	Fair.....	Small, some mosaic and curly dwarf.	Vigorosa×Busola.
64	S-38742.....	Immune.....	Excellent.....	Medium size, considerable mosaic.	Late Blightless×Busola.
65	S-39622.....	Badly warted.	Good.....	Small, healthy.....	Irish Cobbler×Petronius.
66	S-39266.....	Very badly warted.	do.....	Large, some mosaic.....	Early Rockford×Petronius.
67	S-39315.....	do.....	Poor.....	Large, healthy.....	Dibble's Russet×Cacha negra.
68	Seedling.....	Slightly warted.	Fair.....	Medium, some mosaic and curly dwarf.	Parentage unknown.
69	do.....	Moderately warted.	Poor.....	Small, some leaf-roll, curly dwarf, and mosaic.	Do.
70	Bliss Triumph.....	do.....	do.....	Large, much mosaic.....	Triumph group.
71	Green Mountain, Gero strain.	Slightly warted.	do.....	Large, considerable mosaic and curly dwarf.	Green Mountain group.
72	Sutton's Flourball.....	Immune.....	Fair.....	Large, some mosaic.....	Cobbler group.
73	Late Ohio.....	Slightly warted.	Poor.....	Small, much mosaic.....	Early Ohio group.
74	Country Gentleman.....	Badly warted.	do.....	Large, some mosaic and curly dwarf.	Hebron group.
75	Sir Walter Raleigh.....	do.....	Fair.....	Small, much mosaic and curly dwarf.	Rural group.
76	Early Petoskey.....	Immune.....	Good.....	Large, healthy.....	Cobbler group.
77	McIntyre.....	Badly warted.	Fair.....	Small, much mosaic, some curly dwarf.	Related to old variety Carter.
78	Russian Blue.....	Moderately warted.	Poor.....	Small, much mosaic.....	Probably foreign.
79	American Giant.....	Badly warted.	do.....	do.....	American variety.
80	Irish Cobbler.....	Immune.....	Good.....	Large, healthy.....	Cobbler group.
81	Netted Gem.....	Badly warted.	Poor.....	Medium size, some leaf-roll and mosaic.	Burbank group.
82	Bliss Triumph.....	Moderately warted.	Good.....	Large, much mosaic.....	Triumph group.
83	Green Mountain Jr.....	Immune.....	do.....	Medium size, healthy.....	Green Mountain group.
84	White Ohio.....	Very badly warted.	do.....	Large, some mosaic and curly dwarf.	Early Ohio group.
85	Early Rose.....	do.....	do.....	do.....	Rose group.
86	Ehnola.....	Immune.....	do.....	Medium size, some leaf-roll and mosaic.	Early Michigan group.
87	Early Sunrise.....	Very badly warted.	do.....	Large, some mosaic and curly dwarf.	Do.
88	Extra Early Sunlight.....	Immune.....	do.....	Large, healthy.....	Do.
89	Cumming's Pride.....	Very badly warted.	Fair.....	Large, much mosaic.....	Up-to-Date group.
90	Quick Lunch.....	Slightly warted.	do.....	Medium size, all plants showed mosaic.	Triumph group.
91	Early Ohio.....	do.....	Good.....	Small, healthy.....	Early Ohio group.
92	Russet Rural.....	Very badly warted.	do.....	Large, considerable mosaic and curly dwarf.	Rural group.
93	Nonblight.....	do.....	do.....	Small.....	Do.
94	Irish Cobbler.....	Immune.....	do.....	Large, healthy.....	Cobbler group.
95	Bliss Triumph.....	Moderately warted.	Fair.....	Medium size, much mosaic.	Triumph group.

TABLE I.—*The effect of the wart disease on different varieties of potatoes planted near Freeland, Pa., in 1919—Continued.*

Field No.	Variety name.	Reaction to wart disease.	Yield.	Notes on growth and health of vines.	Origin, group, or parentage.
96	Saxony.....	Very badly warted.	Poor.....	Small, some mosaic and leaf-roll.	Foreign variety.
97	Round Pinkeye.....	Immune.....	Fair.....	Large, some mosaic and curly dwarf.	Peachblow group.
98	Pearl.....	Moderately warted.	Poor.....	Small, all plants showed mosaic.	Pearl group.
99	Gurney's White Harvest.	.....do.....	Fair.....	Small, some leaf-roll and mosaic.	Green Mountain group.
100	Evergreen.....	Badly warted.	.....do.....	Medium size, healthy.....	Rose group.
101	Peoples.....	Moderately warted.	Poor.....	Small, some mosaic and curly dwarf.	Pearl group.
102	Vitality.....	.....do.....	.....do.....	Small, much mosaic and some curly dwarf.	Foreign variety.
103	S-24642.....	Badly warted.	.....do.....	Small, healthy.....	Up-to-Date × Round Pinkeye.
104	S-1638.....	Immune.....	Good.....	Large, some leaf-roll.....	Sophie × Keeper.
105	Green Mountain.....	.....do.....	.....do.....	Large, considerable mosaic.	Green Mountain group.
106	Irish Cobbler.....	.....do.....	.....do.....	Large, healthy.....	Cobbler group.
107	Spaulding No. 4.....	.....do.....	Excellent.....	Large, some mosaic.....	Rose group.
108	Variety X.....	Badly warted.	Poor.....	Medium size, much mosaic and curly dwarf.	Local variety, origin unknown.
109	Bliss Triumph.....	Moderately warted.	Good.....	Large, much mosaic.....	Triumph group..

From Table I it will be seen that all the immune English varieties kept their immunity when planted in Pennsylvania. The seed of these varieties was imported from England. Some of it did not arrive in good condition, and this partly accounts for the poor yield given by many of the varieties. Out of the 29 varieties, 7 of them—Edzell Blue, St. Malo Kidney, Rector, Majestic, Arran Rose, Great Scot, and Irish Queen—gave good yields. The Edzell Blue gave an excellent yield of large tubers. In respect to yield this variety compares favorably with many commercial American varieties.

Among the varieties grown more or less extensively for commercial purposes in America, the following were found to be immune to the wart disease: Irish Cobbler, Sutton's Flourball, and Early Petoskey, of the Cobbler group; Ehnola and Extra Early Sunlight, of the Early Michigan group; Spaulding No. 4, of the Rose group; Green Mountain and Green Mountain Jr., of the Green Mountain group; Round Pinkeye, of the Peachblow group; and the Keeper variety, which has not yet been placed in any group. Varieties which warted so badly that the crop was practically ruined are the Early Sunrise, of the Early Michigan group; Early Rose and Evergreen, of the Rose group; White Ohio, of the Early Ohio group; Country Gentleman, of the Hebron group; Netted Gem, of the Burbank group; Rural New Yorker No. 2, Sir Walter Raleigh, Russet Rural, and Nonblight, of the Rural group; Dearborn, of the Pearl group; Producer and Cumming's Pride, of the Up-to-Date group; the Dalmeny Challenge, Eldorado, and Saxony, foreign varieties, and the McIntyre and American Giant, American varieties. Varieties which were moderately warted but not so severely as to ruin the crop are the Bliss

Triumph, of the Triumph group; Late Ohio, of the Early Ohio group; Gurney's White Harvest, of the Green Mountain group; Pearl and Peoples, of the Pearl group; and the Russian Blue, probably a foreign variety. Many of the tubers of the Late Ohio variety showed a few warts. The warts were so small, however, that the disease caused almost no damage to the crop. The stems and stolons of the Russian Blue variety were rather badly warted; the tubers, on the other hand, showed very little warting. Varieties which were so slightly warted that the disease can hardly be said to do any appreciable damage are the Green Mountain Gero strain, Early Ohio, and Quick Lunch. The Quick Lunch variety was somewhat more warted than the Early Ohio or Green Mountain Gero strain.

It is interesting to note the behavior of varieties belonging to the different groups of American potatoes. In the Cobbler group three varieties were tested; all of them proved to be immune. Two varieties of the Triumph group were grown. Both were susceptible to the disease, but showed some resistance. In the Early Michigan group three varieties were tested; two of them are immune, but the third warted very badly. Of the three varieties belonging to the Rose group, two warted badly and one is immune. Three varieties in the Early Ohio group were tested; two were highly resistant and the other is quite susceptible. Only one variety belonging to the Hebron group was grown. It proved to be very susceptible. One variety belonging to the Burbank group was grown; it warted badly. Two varieties belonging to the Green Mountain group are immune; two others are slightly susceptible. Two of the varieties of the Pear group showed some resistance; a third warted badly. Only one variety from the Peachblow group was tested; it proved to be immune. Two varieties from the Up-to-Date group were tested; both are slightly susceptible. It is not possible to predict how a given variety will behave in the presence of the wart, for it frequently happens that immune and susceptible varieties belong in the same group.

Among the seedlings obtained from Prof. William Stuart and tested at Freeland, seven proved to be immune. They are seedlings Nos. 37662, 3165, 38899, 39304, 39168, 38742, and 1638. Seedling No. 37662 is the result of a cross between the Irish Cobbler and Early Petoskey. Both parents are immune to wart, and it is not surprising that the seedling should be immune. Seedling No. 3165 is the result of a cross between the Sophie and Irish Seedling. Nothing is known of the relation of either of these varieties to wart, but the behavior of the seedling suggests that one or both parents may be immune. Seedling No. 38899 is the result of a cross between Prosperity and Fary's, a German starch variety. Seedling No. 39304 is

the result of a cross between Dibble's Russet and McCormick. Dibble's Russet is susceptible to wart; the McCormick has not yet been tested. Seedling No. 39168 is the result of a cross between Green Mountain and Busola. Green Mountain is an immune variety; Busola has not been tested. Seedling No. 38742 is a cross between Late Blightless, a member of the Green Mountain group, and Busola. Neither of these varieties has been tested for resistance to wart. This seedling gave an exceptionally good yield. Seedling No. 1638 is a cross between the Sophie and Keeper. The Keeper is immune to wart.

All the other seedlings tested are more or less susceptible to wart. They are all crosses between susceptible varieties or varieties that have not yet been tested for resistance to wart, with the exception of seedlings Nos. 39500, 39622, and 24642. Seedling No. 39500 is a cross between Irish Cobbler and Busola; seedling No. 39622, between Irish Cobbler and Petronius; and seedling No. 24642, between Up-to-Date and Round Pinkeye. The Irish Cobbler and Round Pinkeye are immune varieties, but in these instances they failed to transmit immunity to their seedlings. Variety X is a blue potato blotched with white and was obtained locally. It gave a poor yield and warted badly.

In Table I those varieties on which no wart was found have been listed as immune. The question might be raised whether a test of one season is sufficient to determine immunity. While there may be some virtue in reserving final judgment regarding the immunity of any given variety, it is believed that a rather thorough test has been made. Most of the American varieties listed as immune were grown alongside of or between susceptible ones. Many of these varieties were severely infected, and there can be no doubt that climatic and seasonal conditions were favorable to the disease. The Sutton's Flourball variety grew between the Green Mountain Gero strain and the Late Ohio. While the Green Mountain Gero strain warted only slightly, the Late Ohio showed rather general warting. The Early Petoskey remained free from wart, although it grew between the Sir Walter Raleigh and McIntyre varieties, both of which warted badly. The Irish Cobbler was planted in three different gardens. In field No. 80 it grew between the American Giant and the Netted Gem; both of these varieties were badly warty. In field No. 94 it grew between Nonblight, which was very badly warty, and Bliss Triumph, which was moderately warty. In No. 106 it grew between Green Mountain and Spaulding No. 4, both of which were immune. The Green Mountain Jr. remained healthy between the Bliss Triumph, which was moderately warty, and White Ohio, which was very badly warty. Ehnola remained free

from wart, growing between Early Rose and Early Sunrise, varieties which warted badly. Extra Early Sunlight showed no wart growing beside Early Sunrise, which was severely warted. Round Pinkeye remained free from wart, growing between Saxony, which was very badly warted, and Pearl, which was moderately warted. Green Mountain was planted between seedling No. 1638 and Irish Cobbler. These varieties are immune, but seedling No. 24642, which grew beside seedling No. 1638 and at a distance of less than 10 feet from Green Mountain, warted badly. Spaulding No. 4 remained free from wart, growing beside Variety X, which warted badly.

The data given in the table show that the susceptibility of American potato varieties varies within wide limits. It is fortunate that a considerable number of varieties are immune, and it is especially fortunate that among this number are to be found some of our most important commercial varieties. But it is a regrettable fact that such valuable sorts as the Rural New Yorker, Early Rose, and American Giant should be very susceptible to the disease. As one observes immune varieties, such as the Irish Cobbler, yielding a good crop among other varieties that are ruined by the disease, he can hardly refrain from wondering what subtle quality in the plant it is that causes potato varieties to behave so differently in the presence of the wart.

The growing of immune varieties in and around infested districts will no doubt help to keep the potato wart from spreading. Several of these varieties are so generally grown that it will not be easy for the disease to gain a foothold in some of our important potato-growing districts, even should it escape from the areas which it now infests.

A NEW HOST FOR THE POTATO WART DISEASE.

By L. O. KUNKEL, formerly Pathologist, Office of Cotton, Truck, and Forage Crop Disease Investigations, and C. R. ORTON, Collaborator, Office of Plant-Disease Survey.

Since the potato contracted the wart in Europe it has been generally supposed that the parasite originally infected some other host. Cotton has reported it on *Solanum nigrum* and *S. dulcamara*, but he never found it on these hosts when they were grown on infested soil in the field. During the fall of 1918 the writers examined a good many different vegetables and weeds that were found growing in infested gardens. Because the potato and tomato are closely related, an especially careful examination was made of tomato plants, but the wart was not found on any other plant than the potato at that time.

Thinking that the tomato might show varietal differences as regards susceptibility to wart, a number of different varieties were

planted on infested soil in the spring of 1919. Two plants of each of 50 varieties of tomatoes were planted in an infested garden at Upper Lehigh, Pa. About half of the varieties were lost, owing to the ravages of a damping-off fungus that apparently came from the seed bed. Those plants that lived were harvested, and while most of the varieties were found to be free from wart, several of them showed the disease. The varieties that were found to have wart are Landreth's Red Rock, Maule's New Imperial, Success, Magnus, Carter's Sunrise, Early Detroit, and Burbank. Wart was found on

the roots and stems of plants belonging to these varieties. The warts on the roots were always small, the largest being about the size of the garden pea. Most of them, however, were not more than half that size. The warts on the stems were considerably larger than those on the roots. They were confined to the underground portions of the stem or to portions just above the surface of the soil. Microscopic examination of the warts on the stems and roots of tomato plants revealed the presence of large numbers of resting sporangia. The warts on the tomato are harder and less succulent than those on the potato. Although a large number of warts on the roots of a tomato plant might lessen

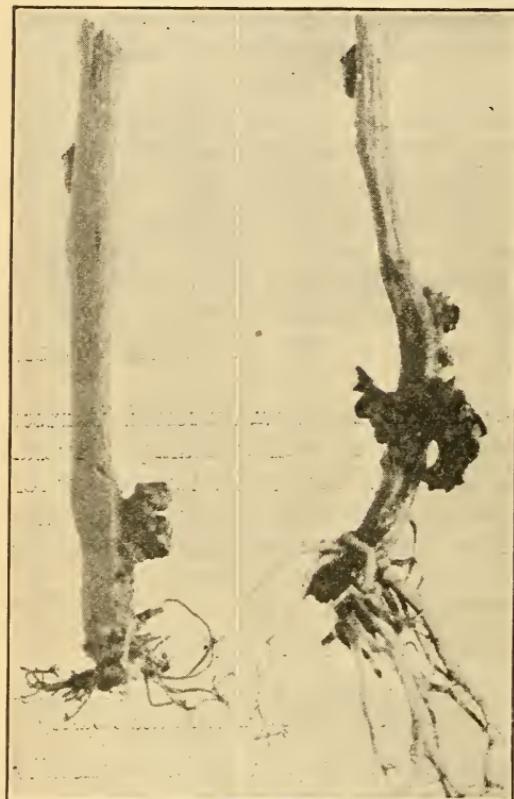


FIG. 4.—Wart on the tomato. Infected stems of plants of Maule's New Imperial variety grown in a wart-infested garden at Upper Lehigh, Pa., in the season of 1919.

somewhat its yield, it is not believed that the disease would cause serious damage to susceptible varieties of this crop; but the growing of certain varieties of tomatoes on infested soil will undoubtedly keep the disease alive from year to year and the transplanting of seedling plants might serve to spread it to new fields. A warted stem of the Maule's New Imperial variety is shown in figure 4.

EXPERIMENTS IN SOIL STERILIZATION FOR THE ERADICATION OF POTATO WART.

Tests conducted at Highland, Pa., during the summer of 1919, in cooperation with the Pennsylvania State College, included trials of steam treatment, using the inverted-pan method and employing various pressures of steam for different periods of time. Another series of experiments was run, to test the effect of hot and cold formaldehyde and combinations of formaldehyde and steam. Various other disinfectants, such as sulphuric acid and mercuric chlorid, were tested, but with inconclusive results. It was found, however, that exposure to live steam under the inverted pan for 85 minutes with a pressure of 90 pounds at the gauge destroyed the potato-wart fungus, in so far as could be determined by planting potatoes on the treated plats. The indications are that a combination of the formaldehyde solution and steam will be more effective than either treatment alone, since these preliminary tests show that the application of $1\frac{1}{2}$ pints of commercial (40 per cent) formaldehyde in 70 gallons of water to 1,000 square feet of surface of soil (about 0.54 pint per square foot) followed by the application of steam at 95 pounds gauge pressure for 30 minutes is efficacious.

These trials are necessarily of a preliminary nature, and it would be unsafe to draw definite conclusions from them. It would appear, however, that there is much hope of eradicating the wart, at least in all the outlying infestations where one or only a few gardens are found infested. These tests will be continued on a larger scale during the season of 1920.

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